

SUPERFUND TREATABILITY CLEARINGHOUSE

Document Reference:

Galson Research Corp. "Bengart and Memel (Bench-Scale), Gulfport (Bench and Pilot-scale), Montana Pole (Bench-scale), and Western Processing (Bench-scale) Treatability Studies." 10 pp. July 1987.

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SUPERFUND TREATABILITY CLEARINGHOUSE ABSTRACT

Treatment Process: Physical/Chemical - Dechlorination

Media: Sludge/Generic

Document Reference: Galson Research Corp. "Bengart and Memel (Bench-Scale), Gulfport (Bench and Pilot-scale), Montana Pole (Bench-scale), and Western Processing (Bench-scale) Treatability Studies." 10 pp. July 1987.

Document Type: Contractor/Vendor Treatability Study

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Site Name: NCBC Gulfport, MS (Non-NPL)

Location of Test: Galson Technical Services, Syracuse, NY

BACKGROUND: This document presents summary data on the results of various treatability studies (bench and pilot scale), conducted at three different sites where soils were contaminated with dioxins or PCBs. The synopsis is meant to show rough performance levels under a variety of different conditions.

The sites discussed are the Naval Construction Battalion Center (NCBC) site Gulfport, MS; Bengart & Memel site, Buffalo, NY; and the Montana Pole site, Butte, MT. No detailed site descriptions were provided. There was no discussion of laboratory analysis procedures, QA/QC plan, or the amount of soils used in bench scale tests.

OPERATIONAL INFORMATION: The APEG process for dechlorinating hydrocarbons was utilized and the amount of reagents/time and temperature were varied. Two different reagent loading rates were used. Tests were conducted in slurry form and in-situ at two of the sites (NCBC and Bengart & Memel). Unit cost estimates for soil treatment are not provided. Costs for each bench-scale test run are estimated at \$1,000 for PCBs and \$2,000 for dioxin. Dioxin tests are more costly due to the complicated analytical procedures. The scope of work for the Montana Pole site treatability study was to see if waste oil containing 100,000 ppb dioxin and 2-3% penta chlorophenol (PCB) could be treated with Galson Terraclene-Cl APEG treatment. The scope of work at the NCBC site was to determine the kinetics of processing dioxin contaminated soil using 30 kg batches in a modified 55-gallon drum reactor unit. The scope of work for the Bengart & Memel treatability study was to determine if PCB contaminated soils could be treated.

PERFORMANCE: The results of the tests on the NCBC site and Bengart & Memel soils are shown on Table 1.

The results of laboratory tests at Montana Pole indicate the reduction had occurred, reducing the dioxin levels from 100,000 ppb to less than 1 ppb after operating the unit for 1 hour at 150°C. The results of the NCBC study showed that the soil from Gulport, MS could be decontaminated by mixing the soil with APEG reagent and heating to 120°C for 7 hours. The results of the Bengart & Memel study indicates the PCB soil could be reduced to less than 50 ppm by adding reagent to the soil, mixing and heating the soil/reagent mass to 120°C for 12-24 hours. However, no significant correlation appears to exist between performance as measured by the amount of contaminant remaining and reagents used, reagent ratios, time, temperature, or reagent loading for all the treatability studies. Contaminant destruction appears to take place in-situ or in soil slurry form.

CONTAMINANTS:

Analytical data is provided in the treatability study report. The breakdown of the contaminants by treatability group is:

<u>Treatability Group</u>	<u>CAS Number</u>	<u>Contaminants</u>
W02-Dioxins/Furans/PCB	1336-36-3	Total PCBs
	30746-58-8	1,2,3,4-Tetrachlorodibenzo- p-dioxin
	TOT-DF	Total dioxins and furans

Note: This is a partial listing of data. Refer to the document for more information.

TABLE 1

BENCH SCALE DATA ON NCBC (GULFPORT)

No.	Source	Compound	Process	Reagent	Loading	Temp. C	Time	Concentration	
								Before	After
1	Gulfport	TCDD	Slurry	9:9:2-P.D.K.	100%	250	4 hours	2000 ppb	<1 ppb
2	Gulfport	TCDD	Slurry	1:1:1-P.D.K.	100%	160	2 hours	2000 ppb	<1 ppb
3	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	150	2 hours	2000 ppb	<1 ppb
4	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	100	2 hours	2000 ppb	<1 ppb
5	Gulfport	TCDD	Slurry	1:1:1-M.D.K.	100%	70	2 hours	2000 ppb	<1 ppb
6	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	70	2 hours	2000 ppb	<1.5 ppb
7	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	70	0.5 hours	2000 ppb	<15 ppb
8	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	50	2 hours	2000 ppb	<23 ppb
9	Gulfport	TCDD	Slurry	9:9:2-M.D.K.	100%	25	2 hours	2000 ppb	<36 ppb
10	Gulfport	TCDD	In-Situ	1:1:1-P.D.K.	20%	25	7 days	2000 ppb	1000 ppb
11	Gulfport	TCDD	In-Situ	1:1:1-P.D.K.	20%	70	1 day	2000 ppb	8.5 ppb
12	Gulfport	TCDD	In-Situ	1:1:1-P.D.K.	20%	70	7 days	2000 ppb	<1 ppb
13	Gulfport	TCDD	In-Situ	2:2:2:1-M.D.K.W.	20%	70	1 day	2000 ppb	3.3 ppb
14	Gulfport	TCDD	In-Situ	2:2:2:1-M.D.K.W.	20%	70	2 days	2000 ppb	2.0 ppb
15	Gulfport	TCDD	In-Situ	2:2:2:1-M.D.K.W.	20%	70	4 days	2000 ppb	2.5 ppb
16	Gulfport	TCDD	In-Situ	2:2:2:1-M.D.K.W.	20%	70	7 days	2000 ppb	<1 ppb
17	Gulfport	TCDD	In-Situ	1:1:1:3-M.D.K.W.	20%	70	7 days	2000 ppb	3.2 ppb
18	Gulfport	TCDD	In-Situ	1:1:1:3-M.S.K.W.	50%	70	7 days	2000 ppb	2.7 ppb
19	Gulfport	TCDD	In-Situ	1:1:1:15-M.D.K.W.	20%	70	7 days	2000 ppb	43 ppb
20	Gulfport	TCDD	In-Situ	1:1:1:15-M.D.K.W.	50%	70	7 days	2000 ppb	14 ppb

BENCH SCALE DATA ON BENGART & MEMEL (BUFFALO)

21	Buffalo	PCB	Slurry	9:9:2:1-M.D.K.W.	100%	100	2 hours	77 ppm	4.2 ppb
22	Buffalo	PCB	Slurry	9:9:2:1-M.S.K.W.	100%	100	2 hours	77 ppm	6.7 ppb
23	Buffalo	PCB	Slurry	1:1:2:2:1-P.T.S.K.W.	100%	150	2 hours	112 ppm	6.7 ppb
24	Buffalo	PCB	In-Situ	2:2:2:1-M.D.K.W.	20%	70	7 days	77 ppm	3.7 ppb
25	Buffalo	PCB	In-Situ	2:2:2:1-M.S.K.W.	20%	70	7 days	77 ppm	4.0 ppb
26	Buffalo	PCB	In-Situ	1:1:2:2:1-P.T.D.K.W.	100%	150	3 days	112 ppm	<0.1 ppb
27	Buffalo	PCB	In-Situ	1:1:2:2:1-P.T.D.K.W.	100%	150	1 day	83 ppm	<0.1 ppb

REAGENT COMPONENTS KEY

D = DMSO = dimethyl sulfoxide
 K = KOH = potassium hydroxide
 M = MEE = methyl carbitol = methoxy-ethoxy-ethanol
 P = PEG = polyethylene glycol, avg. molecular weight of 400
 S = SFLN = sulfolane = tetrahydrothiophene 1.1-dioxide
 T = TMH = triethylene glycol methyl ether and higher
 W = water

TOXIC COMPOUNDS KEY

TCDD = 1,2,3,4-tetrachlorodibenzo-p-dioxin
 PCB = polychlorinated biphenyls

Loading (%) = $100 \times \frac{\text{reagent mass}}{\text{soil mass}}$

Montana Pole

APEG TREATMENT OF DIOXIN- AND FURAN-CONTAMINATED OIL AT AN INACTIVE WOOD TREATING SITE IN BUTTE, MONTANA*

Paul E. des Rosiers[#]

Background

On February 20, 1986, technical staff of the Environmental Protection Agency (EPA), Office of Research and Development's (ORD) Hazardous Waste Engineering Research Laboratory in Cincinnati, Ohio, met with the author, who represented the ORD Office of Environmental Engineering and Technology (OEET), to discuss the provision of technical assistance to EPA Region VIII. Waste at the Montana Pole site is generated as the oily phase of groundwater pumped from 21-foot deep wells; after separation by decantation, approximately 3-percent pentachlorophenol (PCP) in a diesel-like oil is obtained at the rate of 30-50 gpd. This site represents an inactive wood treating facility located on a 20-acre, sloping abandoned mining site, where contamination by dioxins (CDDs) and furans (CDFs) has reached an adjacent creek, including groundwater and surface soil. The PCP-oil waste contained CDD/CDF homologs ranging from 147 ppb of tetra- to 83,923 ppb of octa-congeners. Because of the presence of these potentially highly toxic CDDs and CDFs, the raw oil could not be transported off-site for incineration. The estimated cost of on-site mobile incineration was \$3.1 million.

ORD agreed to assist Region VIII and proposed that a chemical process based on alkali polyethylene glycol (APEG) be employed to decontaminate the oil. Oil samples were obtained from the site and transported to the Brehm Laboratory at Wright State University in Dayton, Ohio, for analysis. Subsequently, parametric studies were conducted to determine treatment conditions to effect optimum decontamination. Tables I and II show that the waste oil was effectively decontaminated by the APEG reagent in the laboratory at conditions as mild as 70°C after 15 minutes.

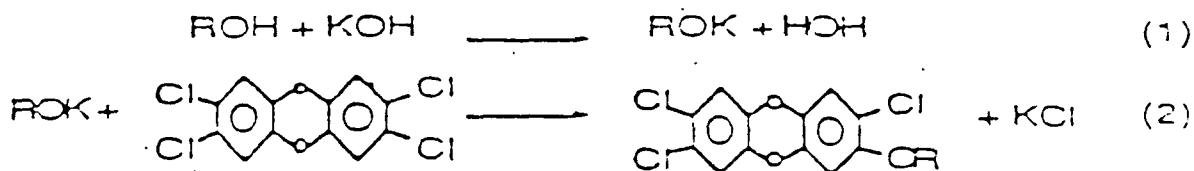
On May 1, 1986, the Region VIII on-scene coordinator agreed to allow treatment of the oil by the APEG process, with ORD technical assistance. Arrangements were made to lease a mobile treatment unit from the Niagara-Mohawk Power Corporation and contracts were signed in June 1986 with both the IT Corporation and Galson Research Corporation to perform the requisite work. Decontamination of the oil was completed on July 31, 1986.

The APEG Process

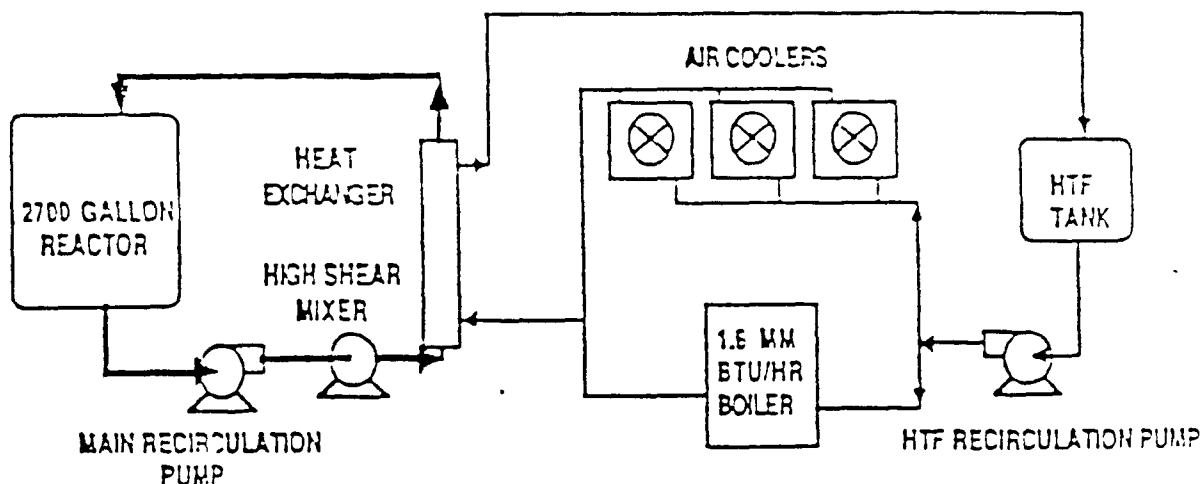
Potassium hydroxide is reacted with polyethylene glycol (molecular weight approximately = 400) to form an alkoxide (see Equation 1). The alkoxide in turn reacts initially with one of the chlorine atoms on the aryl ring to produce an ether and potassium chloride salt (see Equation 2).

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* Paper presented at the Panel on New and Emerging (Waste Treatment and Disposal) Technology, Annual Meeting of the American Wood Preservers Institute, Washington, DC, October 28, 1986.



The mobile field equipment employed to implement the previous chemical process comprises a 2,700-gallon batch reactor mounted on a 45-foot trailer equipped with a boiler/cooling system and a laboratory/control room area. Heating of the raw oily waste/APEG reagent mixture was achieved by the recirculation of the oil and reagent through a pump, a high shear mixer, and a tube-and-shell heat exchanger. The heat transfer fluid on the shell side of the heat exchanger was heated using a boiler or cooled through a series of fin-type air coolers. A schematic is shown below:



Results

The PCP-oil was processed in five batches, each batch consisting of 1,400 to 2,000 gallons of waste oil and 600 gallons of APEG reagent. The mixture was heated to 150°C and allowed to react for 90 minutes before cooling. The reactions conditions were not optimal, however, and were excessive based on results of the Brehm Laboratory parametric studies (see Table I), but were considered a "safety measure" in light of the infancy of the process. The treated oil was then pumped from the reactor into a holding tank from which composite samples were removed and sent to the IT Corporation's analytical laboratory in Knoxville, TN. Table III summarizes both the batch and reagent sludge analytical findings and the destruction efficiencies for CDD/CDF homologs. The data indicate that all CDDs and CDFs were destroyed to concentrations below detection limits, which were, on the average, less than 1 ppb.

The APEG process has therefore successfully destroyed CDDs and CDFs in waste PCP-oil. The processing cost in the Butte, MT, decontamination demonstration was less than 10-percent of the projected, estimated on-site incineration costs--\$212 thousand. The CDD/CDF-free diesel fuel that was obtained will be sold to a local dealer, further reducing the process cost. The purified PCP produced, estimated to be about 1600 pounds, will be stored on-site until its ultimate disposition can be determined.

Additional parametric investigations are planned on the Montana Pole contaminated emulsions, groundwater, and soils. The results of these studies will be reported on next year. The equipment has been transported to Kent, WA, where it processed approximately 8,000 gallons of solvent wastes (a mixture of solvents, oil, and water generated from pesticide manufacturing) containing up to 14 ppb 2,3,7,8-TCDD.

Based on its recent successes on PCBs, PCP-oil, and solvent waste--all contaminated with CDDs and CDFs, the Agency's Dioxin Disposal Advisory Group (DDAG) considers this an innovative and alternative technology, which is also cost effective.

Wastes defined under the Dioxin-Listing Rule (FR 50, 1978-2006) as F021/F027 are considered as acutely hazardous unless treated to < 1 ppb for each of the tetra-, penta-, and hexa-CDD and -CDF homologs according to the Land Disposal Restriction Rules, which become effective on November 8, 1986 (FR 51, 1602-1766) and "delisted" accordingly relative to RCRA Appendix VIII chemicals. Table IV presents recent data concerning 2,3,7,8-TCDD contaminant levels for certain chlorophenols, including PCP, and related organic compounds. Given the "sensitivity" of CDD/CDF contamination of manufactured chemical products and their uses, this list is included here for informational purposes.

Table 1. Parametric Studies of KPEG Treatment of PCP-Oil, Butte, Montana^a

Sample:	Raw Oil	KPEG Treated Oil, ng/g (ppb)							
		70°C						100°C	
		15 min	30 min	45 min	60 min	90 min	120 min	15 min	30 min
CDD/CDF	ppb								
2,3,7,8-TCDD #	28.2	ND (0.762)	ND (0.738)	ND (0.644)	ND (0.322)	ND (0.348)	ND (0.493)	ND (0.858)	ND (0.544)
TCDDs	422	ND (0.456)	ND (0.373)	ND (0.308)	ND (0.305)	ND (0.221)	ND (0.292)	ND (1.25)	ND (0.274)
PCDDs	822	ND (1.01)	ND (0.922)	ND (0.635)	ND (0.396)	ND (0.548)	ND (0.376)	ND (2.09)	ND (0.411)
HxCDDs	2982	ND (1.83)	ND (1.83)	ND (1.38)	ND (0.487)	ND (0.893)	ND (0.516)	ND (3.36)	ND (2.43)
HpCDDs	20671	11.2	2.14	5.82	3.53	4.02	5.50	2.25	1.43
OCDD	83923	6.50	4.01	ND (3.90)	4.24	5.11	4.51	4.14	2.56
2,3,7,8-TCDF #	23.1	12.1	1.28	ND (0.210)	ND (0.191)	ND (0.234)	ND (0.391)	5.45	ND (0.282)
TCDFs	147	33.3	16.3	1.59	ND (0.135)	ND (0.233)	ND (0.212)	109	ND (0.35)
PCDFs	504	ND (0.427)	ND (0.468)	ND (0.421)	ND (0.174)	ND (0.272)	ND (0.153)	ND (0.509)	ND (0.288)
HxCDFs	3918	4.91	2.98	2.82	2.65	2.42	1.63	2.73	ND (0.75)
HpCDFs	5404	5.84	2.63	4.61	2.79	3.72	2.85	ND (0.913)	ND (1.06)
OCDF	6230	ND (3.61)	ND (3.63)	ND (4.86)	ND (2.99)	ND (3.40)	ND (3.69)	ND (3.15)	ND (1.63)

One should not make the erroneous presumption that these data indicate contamination of the PCP by 2,3,7,8-TCDD or 2,3,7,8-TCDF; rather, the most likely source is PCBs, which are present and contain chlorobenzenes. Furthermore, the site has had its share of pit fires further aggravating the situation.

^a Analyses performed by the Brehm Laboratory, Wright State University, Dayton, Ohio.

Table 2. Destruction Efficiency (DE) (%)^{a, b}

Sample: Raw Oil		KPEG Treated Oil			
		70°C		100°C	
Elapsed Time = 30 minutes					
CDDs/CDFs	ppb	ppb	DE	ppb	DE
2,3,7,8-TCDD #	28.2	ND (0.738)	>97.7828	ND (0.544)	>96.2414
TCDDs	422	ND (0.373)	>99.9180	ND (0.274)	>99.8881
PCDDs	822	ND (0.922)	>99.9319	ND (0.411)	>99.9814
HxCDDs	2982	ND (1.83)	>99.9524	ND (2.43)	>99.9031
HpCDDs	20671	2.14	99.9846	1.43	99.9832
OCDD	83923	4.01	99.9942	2.56	99.9936
2,3,7,8-TCDF #	23.1	1.28	93.9583	ND (0.282)	>98.4042
TCDFs	147	16.3	87.3189	ND (0.351)	>99.5015
PCDFs	504	ND (0.468)	>99.9355	ND (0.288)	>99.8888
HxCDFs	3918	2.98	99.9284	ND (0.757)	>99.9671
HpCDFs	5404	2.63	99.9144	ND (1.06)	>99.9624
OCDF	6230	ND (3.63)	>99.9370	ND (1.63)	>99.9285

^a These values are not corrected for small concentrations of HpCDDs, OCDD, and HpCDFs detected in lab blanks, so actual DEs for these isomers are actually higher than indicated.

^b The notation > indicates that the isomer(s) were not detected and the lower limit cited for the DE is based on the analytical detection limit.

Source of the 2,3,7,8-TCDD/TCDF is PCBs, which contain chlorobenzenes, and have experienced thermal stress, namely, pit fires.

Table 3. Results of APEG Chemical Detoxification of PCP-Oil
Montana Pole Site^b, Butte, Montana

CDD/CDF Homolog	Raw PCP-Oil	KPEG-Treated Oil @ 150°C, 90 min					Reagent Sludge		DEs
	ng/g	ng/g							Σ ^a
		Batch No.:							
		1	2	3	4	5			
TCDDs	422	(0.64)	(0.68)	(0.82)	(0.75)	(0.80)	(0.12)	(0.73)	>99.98
PCDDs	822	(0.97)	(0.49)	(0.78)	(0.52)	(0.74)	(1.0)	(0.70)	>99.91
HxCDDs	2,982	(0.92)	(0.63)	(0.43)	(0.70)	(0.90)	(0.44)	(0.76)	>99.97
HpCDDs	20,671	(0.41)	(0.52)	(0.32)	(0.39)	(0.47)	(0.18)	(0.48)	>99.99
OCDD	83,923	(1.3)	(0.87)	(1.1)	(0.54)	(1.1)	(1.0)	(0.98)	>99.99
TCDFs	147	(0.77)	(0.59)	(0.83)	(0.62)	(1.5)	(0.14)	(0.86)	>99.41
PCDFs	504	(1.3)	(0.58)	(0.66)	(0.67)	(1.1)	(0.51)	(0.81)	>99.84
HxCDFs	3,918	(0.84)	(0.53)	(2.2)	(0.67)	(2.1)	(0.49)	(1.27)	>99.97
HpCDFs	5,404	(0.49)	(1.0)	(1.6)	(0.56)	(0.83)	(0.28)	(1.09)	>99.98
OCDF	6,230	(0.53)	(1.3)	(1.1)	(0.61)	(0.83)	(0.22)	(0.67)	>99.99

() = detection limit. Analyses performed by IT Corporation, Knoxville, TN;
QA/QC performed by EPA EMSL-Las Vegas, NV.

a = detection limit (DL) averaged for five batches;
destruction efficiency (DE) based on average DL of homolog.
(The notation > indicates that the homologs were not detected and
the lower limit cited for the DE is based on the average of the
analytical detection limit.)

b = oil processed July 25-31, 1986; in addition, wipe samples of equipment
after decontamination procedures completed showed: no TCDDs/TCDFs, PCDFs,
HxCDDs/HxCDFs, or OCDF detected at or above DL = 3.8 ng/m²; only PCDD =
36 ng/m² and OCDD = 217 ng/m² were found above the DL. These positive
values are well below any concentration considered to be of concern
according to EPA ORD ECAO-Cincinnati and EMSL-Las Vegas laboratories.

Table 4. Levels of 2,3,7,8-TCDD in Commercial Chlorophenols and Related Compounds^b

Product	2,3,7,8-TCDD ng/g (ppb)	Source
trichlorobenzene	95	Dynamit Nobel
Witophen Na ^a	0.42	Dynamit Nobel
Preventol PN	0.56	Bayer AG
Dowicide G	0.21	Fluka
Witophen P (sample 1)	n.d.*	Dynamit Nobel
Witophen P (sample 2)	n.d.*	Dynamit Nobel
PCP sample	n.d.*	Rhône-Poulenc
2,4-D	6.8	EGA-Chemie
hexachlorophene	0.3	Riedel-de Haen
2,3,4,5-TCP	0.3	Aldrich
chloranil	n.d. [#]	Hoechst AG

* Limit of detection for all three analyses was approximately 0.03 ng/g.

[#] Detection limit = 0.05 ng/g.

^a Na-pentachlorophenate.

^b H. Hagenmaier (1986). Determination of 2,3,7,8-tetrachlorodibenzo-p-dioxin in commercial chlorophenols and related compounds. For publication in: Fresenius Z. Anal. Chemie.

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Bengart + Memel

DECONTAMINATION OF A SMALL PCB SOIL SITE
BY THE GALSON APEG PROCESS

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Presented before the Division of Environmental Chemistry
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ABSTRACT

In 1985, a total of fifty-two drums of PCB contaminated soil were chemically decontaminated using an early version of the patented APEG process developed by Galson Research Corporation.⁽¹⁾ The fifty-five gallon drums containing the contaminated soil were also used as reaction vessels. Processing involved adding liquid reagents to saturate the soil. The drums were then heated to at least 100°C for 2-3 days without mixing. The PCB concentration in all of the drums was reduced to below 50 ppm, the required "clean" level for this site. The treated soil was neutralized by mixing with dilute acid. The excess liquid was then decanted from the soil, with the treated soil approved for return to the original excavation.

Small sites could use this process as a cost effective alternative to incineration or landfill. A more sophisticated multi-ton slurry reactor system is currently being designed for larger sites.

INTRODUCTION

Galson Research has patented (1) a chemical process which detoxifies hazardous aromatic halides in contaminated soil. The APEG (alkaline-polyethylene glycolate) process has been proven successful for a variety of soils in both laboratory and field studies. The procedure used at the Bengart & Memel site was a small scale version of the process, which utilized the soil storage drums as reaction vessels.

The APEG process entails the addition of liquid reagents to contaminated soil and heating of the mixture until the PCBs in the soil decompose to lower toxicity, water soluble materials. The reactions involved are shown in Figure 1.

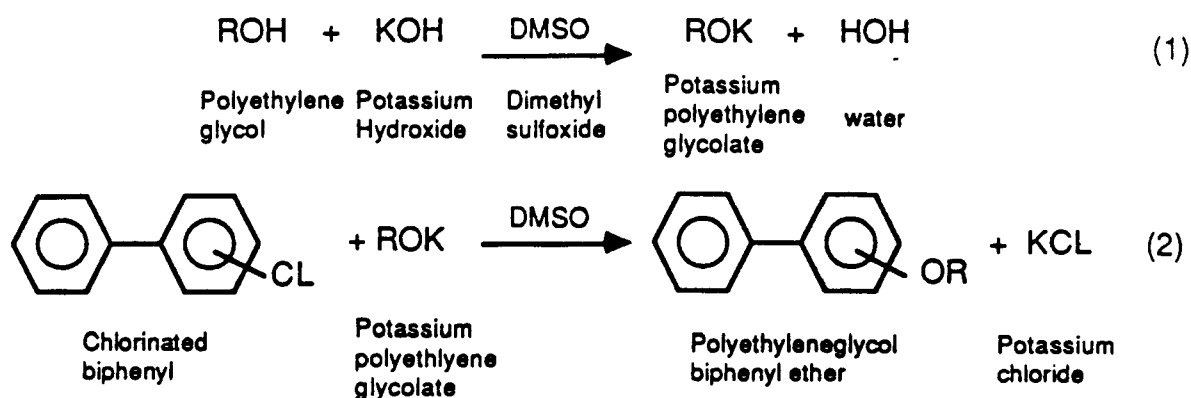


Figure 1. Reactions

The reagent components include: a sulfoxide, e.g. sulfolane or dimethyl sulfoxide (DMSO); a glycol or capped glycol, e.g. polyethylene glycol 400 (PEG), triethylene glycol methyl ether and higher (TMH), and/or methyl carbitol (MEE); solid or aqueous potassium hydroxide (KOH); and water. The glycol is reacted with KOH in the presence of DMSO to form an alkoxide. The alkoxide reacts with one of the chlorine atoms on the biphenyl ring to produce an ether and potassium chloride salt. The sulfoxide acts as a cosolvent/catalyst and increases the overall rate of reaction.

SITE BACKGROUND

Bengart & Memel, Inc. a wholesaler of non-ferrous scrap metals, was originally founded in 1950 in Buffalo, New York. From the early 1950's through 1978 Bengart & Memel received and dismantled PCB (polychlorinated biphenyl) transformers and capacitors, inadvertently releasing PCB into the soil. In the mid-1970's, soil samples from the property were found to contain greater than 50 ppm of PCBs. The New York State Department of Environmental Conservation issued a Consent Order for remediation which required that the PCB concentration in the soil be reduced to below 50 parts per million. (2, 3)

Soil sampling and analysis indicated that seven sites on the property had excessive PCB concentrations. These sites ranged in depth from 6 to 24 inches and were defined to be 10 feet in diameter about the point where the soil core sample was taken. As part of the remedial program, this soil was excavated and placed in a total of 166 fifty-five gallon steel drums.

PROJECT ORGANIZATION

The processing of PCB contaminated soil at Bengart-Memel proceeded in 3 stages; analysis of each drum for PCB concentration, laboratory simulation of PCB destruction and neutralization, and actual treatment operations at the site.

ANALYSIS OF EACH DRUM FOR PCB CONCENTRATION

Galson Research Corporation sampled each of 188 drums and analyzed the soil for PCB concentrations using the McGraw-Edison PCB Field Test Kit. The kit was used to avoid using the more expensive gas chromatograph (GC) analyses for every drum. Twenty two samples which were near 50 ppm by the kit were analyzed by GC to establish a relationship between the analytical methods. A conservative correlation derived from these results indicated that only those samples between 25 and 60 ppm as determined by kit analysis needed to be re-analyzed by GC. A total of 39 samples fell into this range. These samples were analyzed by an EPA contract laboratory, Carolina Chemists & Consultants (CCC). Of the 61 samples analyzed by both kit and GC (GRC and CCC combined), only 14 drums were incorrectly classified as needing treatment by kit analysis (false positives). This amounts to 77% precision for kit results in the 23 to 60 ppm range.

Both GRC and CCC ran three sets of duplicates; CCC had an average deviation from the mean of 13.5%, GRC had an average deviation of 12.9%. Using a +/- 14% variation applied to the cutoff point of 50 ppm, all drums 43 ppm and higher were deemed to require remediation; this conservative approach insured an accurate classification of drums. This cutoff point is even more conservative considering that the samples analyzed consisted of soil devoid of the heavy, non-porous debris (e. g., gravel, rocks and metal) which made up a significant portion (ca. 20%) of the drum contents. The table below contains a summary of the drum classification.

Table 1 - Analytical Methods by which Drums were Segregated

	KIT	GRC GC	CCC GC	TOTAL
Requires Treatment	67	17	10	94
No Treatment Needed	38	5	29	72

Ninety-four of these drums were determined to be above the 50 parts per million PCB concentration which classified them as hazardous waste requiring remediation.

LABORATORY SIMULATION OF PROCESS

Soil from the Bengart & Memel site was passed through a screen with 0.25" openings to remove rocks and thoroughly mixed before being used for laboratory treatment simulations. Five laboratory experiments were conducted.

1. Two Phase Reagent Tests
2. Reagent Formulation Experiment
3. Single Phase Reagent Tests
4. Effect of Sample Size on Reaction Rate
5. Effect of Temperature on Reaction Rate

Each set of tests will be discussed separately.

Two Phase Reagent Tests

Earlier laboratory work done by GRC (4) with soil from this site showed that treatment at 70°C with 2:2:2:1 DMSO:MEE:KOH:water at 20% loading (10 g reagent for 50 g soil) reduced average PCB concentrations from 77 ppm to 16 ppm (standard deviation = $s = 5.0$, number of samples = $n = 3$). Treatment with 2:2:2:1 SFLN:MEE:KOH:water at the same temperature and reagent loading reduced the PCB concentration from 77 ppm to 14 ppm ($s=0.6$, $n=3$). When 120 lb batches of soil were treated at 70°C using the same reagent formulation, the results were more variable, with little or no PCB reduction in some cases.

Because processing at 70°C was ineffective in the pilot test, additional laboratory reactions were conducted at higher temperature (150°C), using a more potent reagent formulation, (1:12:2:1 PEG:TMH:DMSO:KOH:water), at 100% loading (50 g reagent for 50 g soil). This approach was quite successful. After 3 days of reaction, the average PCB concentration in the soil was <0.1 ppm. The reaction was repeated with a reaction time of 24 hours. Again, the PCB concentration was <0.1 ppm. This general approach was used for the full scale cleanup.

Reagent Formulation Experiment

It was believed that much of the failure to scale up the unmixed soil process was due to the fact that the solid KOH used for the reagent was not evenly distributed through the soil. Previous work done by GRC (4) had shown that reagent formulated with saturated aqueous KOH (2:2:2:1 PEG:DMSO:KOH:water) instead of solid KOH (1:1:1 PEG:DMSO:KOH) forms a 2 phase liquid mixture and that reagent containing 50% water (2:2:2:6 PEG:DMSO:KOH:water) is a single liquid phase. Use of a single phase reagent promotes even distribution of reagent throughout the soil. However, since water slows down the reaction, it would have to be removed by heating and evaporation. The less water added to the reagent, the less time and energy needed to remove the water. In addition, 1:1 PEG:TMH mixture produces a more effective reagent than PEG alone. Thus, a reagent of the formulation 1:1:2:2:X PEG:TMH:DMSO:KOH:water was proposed for this project. The value of X was to be the minimum amount of water that would produce a single phase

reagent. Experimentation showed that a minimum 44.6% water was necessary to produce a single phase reagent. A close approximation, with a slight safety factor was a formulation of 1:1:2:2:5 PEG:TMH:DMSO:KOH (dry):water, which is 45.5% water by weight. Since the KOH used in the field was available as a 45% aqueous solution, the formulation used at the site became 2:2:4:9:5 PEG:TMH:DMSO:45% KOH:water.

Single Phase Reagent Tests

Samples of screened soil weighing 10 g were treated with 4 g of the single phase reagent and heated to 150°C for 24 and 48 hour intervals. The samples were cooled and analyzed along with samples of untreated soil. On the average, the process reduced the PCB concentration in the soil from 116 ppm (s=9.2, n=3) starting to 6.3 ppm (s=1.4, n=3) in 24 hours and to 3.3 ppm (s=1.2, n=3) in 48 hours.

Effects of Sample Size on Reaction Rate

A treatment simulation was done to investigate the effect of reactor size on reaction effectiveness and to produce a single batch of soil for checking spike recovery from treated samples. For this simulation, a 237.2 g sample of screened soil was treated with 83.3 g of single phase reagent. Three portions of the soil were extracted and analyzed, one portion was spiked with an additional 2.2 ppm of Aroclor 1260 (added as a hexane solution). The larger scale reaction reduced the PCB concentration to 8.8 (s=1.1) ppm in 48 hours. Spike recovery from the treated soil was 153%. There is not enough data to state that the difference between the larger and smaller reactions is statistically significant.

Effect of Temperature on Reaction Rate

A laboratory treatment simulation was done to simulate the lower temperature and slow heating predicted for field operations. The lowest third of the soil volume was immersed in an oil bath and the bath was heated slowly, at 20°C/hour, to 115°C. The lower temperature and slow heating reduced the reaction efficiency but still reduced the PCB concentration to <50 ppm within 48 hours.

Summary of Laboratory Results

Table 2 is a summary of all of the laboratory testing done for this project.

Table 2. Laboratory Results

Description/Reagent	%L	T	days	n	ppm	s
Two phase reagent tests						
1:1:2:2:1 PEG:TMH:DMSO:KOH:water	100	150	3	2	<0.1	0.07
untreated	na	na	na	2	112	6.4
1:1:2:2:1 PEG:TMH:DMSO:KOH:water	100	150	1	2	<0.1	<0.05
1:1:2 PEG:TMH:DMSO (control)	100	150	1	1	27	na
untreated	na	na	na	1	83	na
Single phase reagent tests						
1:1:2:2:5 PEG:TMH:DMSO:KOH:water (small)	40	150	1	3	6.3	1.4
1:1:2:2:5 PEG:TMH:DMSO:KOH:water (small)	40	150	2	3	3.3	1.2
1:1:2:2:5 PEG:TMH:DMSO:KOH:water (large)	40	150	2	3	8.8	1.1
1:1:2:2:5 PEG:TMH:DMSO:KOH:water (small)	45	115	1	1	97	na
1:1:2:2:5 PEG:TMH:DMSO:KOH:water (small)	45	115	2	1	30	na
untreated	na	na	na	3	116	9.2

%L = % Loading = g reagent/100 g soil
n = number of samples
s = standard deviation

T = Bath Temperature in °C
ppm = Average mg PCB/kg soil
na = not applicable

Neutralization Testing

In order to discharge the treated soil, it was necessary to reduce the soil pH from over 14 to between 5 and 9. Neutralization was simulated under laboratory conditions. Two 10 g samples from the 150°C treatment simulation were neutralized by addition of 4 mL of 3 M HCl. Another pair of samples were treated with 4 mL deionized water for comparison. The samples were allowed to stand until foaming subsided in the acid treated samples. The samples were then mixed with a sonicator for 5 minutes and shaken vigorously. After standing (capped) for about 60 hours the pH of the free liquid in the vials was checked using Hydriion pH paper.

Neutralization of the soil by addition of hydrochloric acid reduced the pH of the treated soil from greater than 12 to 6, but the procedure was somewhat hazardous. The reaction between treated soil and acid produced a great deal of bubbling and foam. For that reason, the field neutralization was done with more dilute acid.

OPERATIONS/PROCESSING PROCEDURES

The bulk of the decontamination processing took place in September and October of 1986. Fifty-one drums of soil were staged near the work area for decontamination. Due to the consent order deadline, the remaining drums were not processed and were shipped to a landfill. The only exception was drum #20 which could not be disposed in a landfill due to the >500 ppm concentration. A confirmatory GC analysis of the soil gave a PCB level of 1300 ppm. Drum 20 was eventually processed in February 1987, during neutralization of the other drums.

Soil decontamination at Bengart & Memel involved 6 basic steps;

1. Set up of the vapor system & enclosure.
2. Add premixed liquid reagent to soil drums.
3. Attach heaters, insulation, and vent lines to the drums.
4. Allow drum contents to heat and react.
5. Cool and obtain sample for analysis.
6. Neutralize the caustic soil.

The soil filled the drums to within two to six inches from the top to allow for the addition of the liquid reagents. An aluminum tube was driven through the dry soil to the bottom of the drum to allow air to escape during liquid addition, otherwise an air pocket would form preventing the downward movement of the liquid. The single phase reagent mixture (2:2:4:9:5 PEG:TMH:DMSO:45% KOH:water) was added to the soil drums by weight, typically between 150 - 170 pounds. The KOH reacted with aluminum, thus when the reagent reached the bottom of the drum, foam exiting the tube would indicate that the air pocket had been expelled. The tube was then removed and a bimetal thermometer was inserted into the 3/4" bung on the drum cover.

The drums were heated from the bottom to insure that all of the soil was reacted. Dents and deformities in the drums necessitated the use of heat transfer compound in order to provide adequate contact between the heaters and the metal. It was essential that liquid be contacting the metal on the interior so that the heat could be carried away. The soil temperature was monitored 9 to 12 inches below the lid with the heaters were at the drum's base. Soil temperatures near the heater were higher than those measured near the top. Typically a drum would be heated to a maximum temperature readout between 105 and 110°C for several hours.

The drums were vented to a central condenser system with a capacity of 16 drums (See Figure 2). During heating, vapors would exit from the drum through an insulated, flexible line connecting the 2" drum bung to the main header. Part of the header was ice jacketed so that much of the water vapor was condensed and drained directly into a 55 gallon holding drum. The remaining vapor was drawn through an air cooled radiator (used as a condenser) which also drained liquid to the 55 gallon holding drum. An ice jacketed scrubber containing a dilute sodium hypochlorite solution (for odor control) trapped most of the remaining condensables. From the scrubber, the

vapor passed through an air trap and a 55 gallon drum which was filled with a mixture of activated carbon and molecular sieve. A vacuum pump provided negative pressure for the vapor control system.

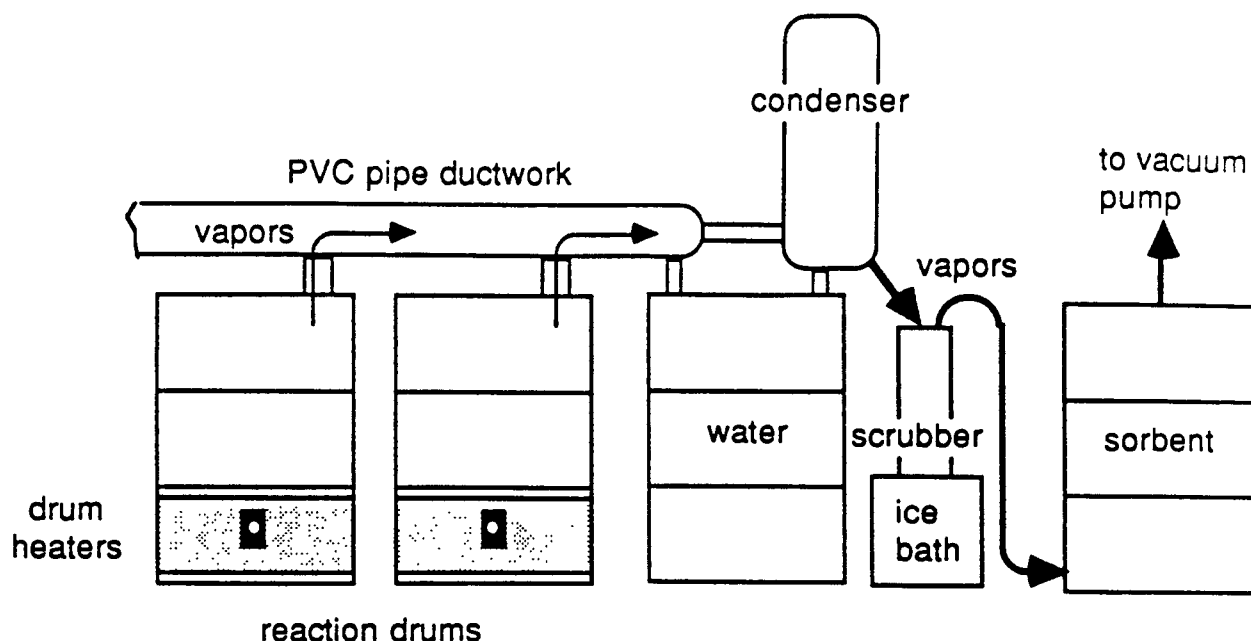


Figure 2. - Central Condenser System

Treated soil samples were collected using a 30 inch auger attached to a hand drill. Four wells were made in each drum, one in the center, one close to the edge and two spaced between the center and edge in different parts of the drum. Soil was collected by digging as deep as possible with the auger and bringing soil up from the bottom of the hole. In digging out a sample well, it was necessary to work around the large rocks in the drum -- true core samples were not obtainable. Debris (rocks, metal, wood, etc.) larger than 1 inch in diameter was not included in the sample. The soil from the cores was collected in a plastic bucket and mixed thoroughly with a trowel. Two jars were filled for each sample, one for GRC and one for the EPA. The soil remaining in the bucket was returned to the drum and the auger, bucket, and trowel were cleaned before the next drum was sampled to avoid cross contamination.

Once the treated soil had been decontaminated, the soil had to be brought from a caustic state to a neutral pH. Mixing was necessary to avoid 'hot spots' of concentrated acid or caustic. To provide controlled mixing, it was decided to add the alkaline soil slowly to a drum partially full of dilute acid. When the liquid

became neutral or slightly basic, more acid was added to compensate. Thus when the acid and KOH reacted, there was sufficient mass to absorb the heat and prevent splattering. This procedure required frequent monitoring for pH control.

PROCESS RESULTS

PCB Analysis

The analytical results for PCB from this project can be divided into two groups. Group 1 consists of samples that were analyzed by the EPA soon after processing and found to contain less than 50 ppm of PCB. The drums from which the Group 1 samples were taken were neutralized without any further sampling or treatment. The concentrations in the untreated soil and EPA results for the treated soil are summarized in Table 3.

Table 3. Sample Group 1, Analyzed only by EPA

Drum	ppm PCB in untreated soil	ppm PCB in treated soil 10/86
5	119	43
6	119	46
8	62	45
10	128	46
35	910	33
36	91	46
46	123	47
53	64	15
60	61	44
62	65	30
71	69	28
81	74	38
82	67	43
87	62	39
91	91	37
92	138	49
93	91	44
102	69	18
109	87	42
119	64	9
137	62	23
average	125	36

Group 2 was analyzed by GRC in February of 1987. This group includes fresh samples from the drums that were over 50 ppm when the EPA analyzed them in October 1986, samples from drums that were never analyzed by the EPA and one sample that was already less than 50 ppm when the EPA analyzed it. All of these drums were sampled in February 1987, after the reagent had been in contact with the soil for 5 months. The low concentration sample analyzed by GRC to check the potential reaction progress in drums with PCB concentrations below 50 ppm. Results of GRC's analyses are presented in Table 4.

Table 4. Sample Group 2, Analyzed by GRC

Drum	ppm PCB in untreated soil	ppm PCB in treated soil by EPA 10/86	ppm PCB in treated soil by GRC 2/87
1	138	71	19
4	84	60	20
9	64		8
11	128	90	30
20A	1300		<5
20B	1300		94
37	64	74	12
43	102		7
44	72	51	31
45	195	59	27
54A	78		10
54B	78		49
63	167		16
64	64		13
72	119		12
83	78		18
85	78	56	16
86	84	74	22
101	74		11
111	64	51	22
112	110		33
113	67	78	17
114	102	57	27
120	75	26	<5
121	62		24
122	106	65	22
131	78		17
135	106		28
Misc A	NA		33
Misc B	NA		17
Misc C	NA		9
Misc D	NA		6
Misc E	NA		15
average	179.	62	22

*This drum not approved for non-PCB disposal.

NA = Not Analyzed

The reduced concentrations reported in February (compared with October results) indicate that the reaction continued during the holding period.

The only soil not to be reduced to below 50 ppm was from a drum of particularly high concentration (drum #20 @ 1300 ppm) that the site owner was not able to landfill. Drum 20 and drum 54 were processed in February 1987 during the neutralization procedures. The soil from these drums were split and transferred into two drums (20A & 20B, 54A & 54B) to insure good reagent permeation and better heat transfer. The PCB level was reduced by 93% in drum 20B, to between 73 ppm and 104 ppm. Drums 20A, 54A & 54B were all reduced to less than 50 ppm.

Soil Neutralization

The drums of soil were neutralized between February 11 and 26, 1987. They were allowed to rest until March 27 and the pH was re-checked. Additional acid was added to those drums having a pH above 9. The pH of those drums was checked the following day. Results are presented in Table 5.

Table 5. Results of Soil Neutralization at Bengart & Memel Site

pH of Saturated Soil

DRUM	27-Mar-87	28-Mar-87	DRUM	27-Mar-87	28-Mar-87
1	8		101	7	
3	7		109	13	6
4	8		111	12	8
6	11	6	113	7	
8	7		114	7	
9	7		119	10	6
10	11	6	120	9	6
11	10	5	121	6	
36	7		122	7	
37	9	6	131	10	6
43	6		135	13	6
46	8		137	8	
53	7		20A	7	
60	6		20B	6	
63	8		OF-1	11	6
64	7		OF-2	8	
71	8		OF-3	7	
72	8		I	10	6
81	10	5	II	8	
82	11	7	III	10	6
83	8		IV	11	7
85	9		VII	10	8
91	12	5	MISC A	7	
92	9	9	MISC B	7	
93	8		MISC D	8	
			MISC E	7	

Drums designated OF were overflow from other drums during neutralization.
Drums that lost their Arabic numerals during handling were re-labeled with Roman numerals.

CONCLUSIONS

The early form of APEG processing used at the Bengart-Memel site was successful in reducing PCB levels for 51 of 52 drums to below the 50 ppm control limit set for the site. For the 51 successful drums, the average PCB levels were reduced 75%, from 108 ppm to 27 ppm. PCB levels for the sole remaining drum were reduced by 93%, from 1300 ppm to 78 ppm.

A more advanced form of the GRC APEG process is under development. This new process features mechanical mixing of reagent and soil, along with reagent recovery. However, the early form of the process described here should prove cost effective for small sites, especially where the soil can be allowed to react for long periods of time.

ACKNOWLEDGEMENTS

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The assistance of Alfred Kornel of EPA Cincinnati in providing PCB analysis is gratefully acknowledged.

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Gulfport

COMPARISON OF LABORATORY AND FIELD TEST DATA IN THE CHEMICAL DECONTAMINATION OF DIOXIN CONTAMINATED SOILS

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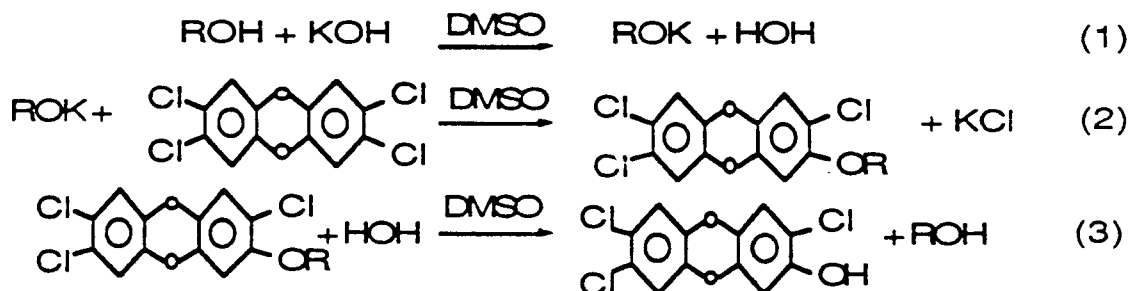
Galson Research Corporation has developed a series of patented (1) processes for chemical decontamination of soils contaminated with halogenated aromatics, including polychlorinated dibenzo-p-dioxins (PCDDs), chlorinated benzenes, polychlorinated biphenyls and similar materials. These processes allow reduction of PCDD levels to < 1 part per billion (ppb) in as little as two hours at moderate temperatures and pressures.

Introduction

Chemical decontamination is an alternative to thermal processing or landfilling of soils contaminated with polychlorinated dibenzo-p-dioxins (PCDDs) or other aromatic halides such as chlorobenzenes or polychlorinated biphenyls (PCBs). Chemical decontamination, like incineration, involves changes to the chemical structure of the dioxin molecule. While chlorinated dioxins are thermally stable, they readily dechlorinate to water soluble compounds under relatively mild conditions of temperature and pressure. For example, chlorinated dioxins in oil are readily reduced to the ppt level within 15 minutes at 80 degrees C. by reacting them to a compound which is no longer oil soluble. In soils processing, the dioxin is dechlorinated to a water soluble form which is then leached from the soil using countercurrent extraction with water. Dechlorination also affects the toxicity of the dioxin, with dioxins containing fewer than three chlorine atoms generally showing low toxicity (2).

Process Chemistry

The proposed mechanism for these reactions is shown below using 2,3,7,8 tetrachlorodibenzo-p-dioxin as an example;



An alkali metal hydroxide, usually potassium hydroxide (KOH) is reacted with an alcohol or glycol such as polyethylene glycol 400 (PEG 400) to form an alkoxide. The alkoxide reacts with one of the chlorine atoms on the chlorinated dioxin to produce an ether and the alkali metal salt. This dechlorination may proceed to complete dechlorination, although replacement of a single chlorine is sufficient to make the reaction products water soluble. The ether formed by the dechlorination may degrade to a phenol form or may remain as the ether, depending on the reaction conditions. The processing is carried out using dimethyl sulfoxide (DMSO) as a solvent. The DMSO catalyzes the reaction by increasing the base strength of the alkoxide. In addition, the DMSO aids in the extraction of the PCDD from the soil.

Toxicity Considerations

Chemical decontamination of soil is a two stage process;

1. Dechlorinate PCDD to lower toxicity/ water soluble form
2. Wash excess reagents and PCDD products from soil

A major concern in this type of processing involves the toxicity of any reagents and/or reaction products which may inadvertently be left in the decontaminated soil after treatment. Some toxicity data on reagents used in the process are shown in Table I, along with comparison values for sodium chloride and 2,3,7,8 TCDD.

Table I - Toxicity of Reagents and Comparison Materials

Material	LD50, Oral-rat (3)
polyethylene glycol 400	27,500 mg/kg
dimethyl sulfoxide	17,500 mg/kg
sodium chloride (comparison value)	3,000 mg/kg
2,3,7,8 TCDD (comparison value)	0.022 mg/kg

The reagents used in this process are some five times less toxic than table salt, and roughly six orders of magnitude less toxic than 2,3,7,8 TCDD, the dioxin isomer of major concern. Polyethylene glycol 400 is an FDA approved material for use in foods and cosmetics. Dimethyl sulfoxide is a naturally occurring material in foods such as potatoes, milk and coffee at the part per million level. Expected residual levels of these materials in soil are not expected to be a serious concern.

Toxicity testing of the reacted aromatic halides is currently underway with EPA sponsorship. Structural assessment of the theoretical toxicity of the reaction products is favorable, ie the known reaction products would not be expected to show significant toxicity. Results of the Ames test for mutagenicity are negative, ie the reaction products do not demonstrate carcinogenic potential. Bioaccumulation tests also produced negative results, which is not surprising given the water solubility of these reaction products. Acute toxicity tests are currently (April, 1986) in progress.

Process Description

The decontamination of soil proceeds in a series of six process steps.

1. Combine equal masses of soil and reagent to form a slurry
2. Mix and heat soil/reagent slurry to 100-180 °C
3. Allow to react 1-5 hours
4. Decant excess reagent
5. Wash soil 2-3 times with water
6. Discharge decontaminated soil

This process is shown in diagram form below;

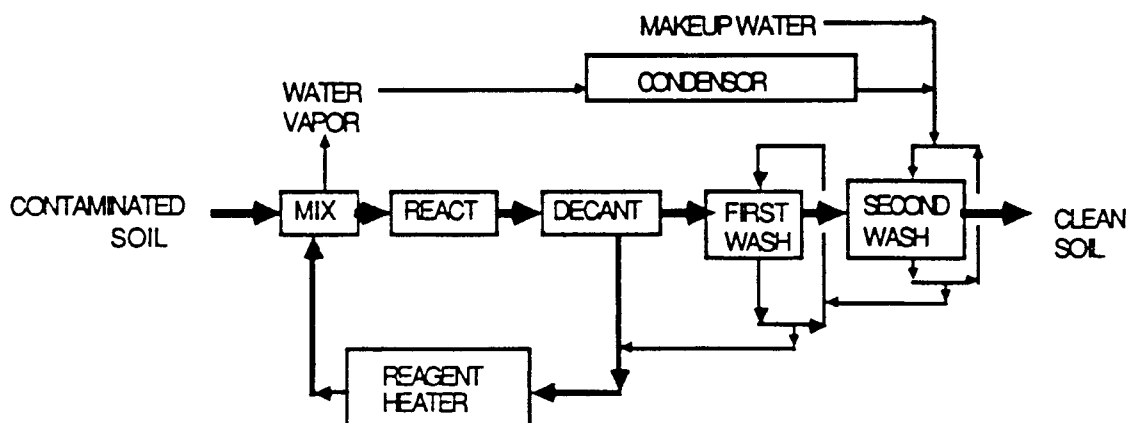


Figure 1 - Soil Decontamination Process

All of the process steps can be conducted in a single agitated reactor. The number of wash steps required will depend on the effectiveness of each wash step and on the degree of reagent recovery required.

Results of Tests to Date

Three series of tests using dioxin contaminated soil have been conducted to date: laboratory tests at high and low rates of agitation and field tests at low agitation only. Each set is discussed separately.

Laboratory Testing - High agitation

Initial laboratory tests used 250 g. soil samples spiked to a nominal concentration of 2000 parts per billion (ppb) of 1,2,3,4 TCDD. The 1,2,3,4 isomer was used in place of the 2,3,7,8 TCDD isomer to simplify experimental and safety procedures. These tests used an electrically heated 1000 mL three neck flask equipped with a reflux condenser and high torque agitator to provide a high degree of mixing.

In the initial series of experiments a Teflon paddle was used with the agitator. Analysis of the treated soil samples revealed the presence of an unknown halogenated contaminant which was later determined to be partially decomposed Teflon. The combination of reagent and erosion from the soil had broken down the Teflon used in the agitator. This interference required some additional sample cleanup. Changing to a glass paddle solved the problem for laboratory testing.

Treated samples were analyzed by three different labs using either gas chromatography/mass spectroscopy (GC/MS) or GC/MS/MS methods. Analysis by gas chromatography alone was unsuccessful, partly due to the Teflon interferences previously noted. The results of this initial testing are summarized below, with all samples having a nominal initial concentration of 2200 parts per billion;

Table II - Results of Laboratory Testing with High Agitation
Initial Concentration 2200 ppb

Reaction Temperature, °C	Reaction Time, Hours	Final TCDD Concentration, ppb
260	4	<1
150	2	<1
100	2	<0.2
70	0.5	15
70	2	<1
50	2	29
25	2	36

These tests indicated that while reaction rates for soils were lower than those obtained in oil tests, the overall reaction times were reasonable for large scale application.

Laboratory Testing - Low Agitation

After design of the field test equipment, it became apparent that the degree of agitation obtained in the initial laboratory tests was not going to be achieved in the field. Therefore, tests were conducted at a low rate of agitation to provide a prediction of the probable results of field testing. This testing used a flask equipped with a condenser and inserted into a heated oil bath. Agitation was provided by manually swirling the flask and contents at periodic intervals. Soil for this test was the same soil to be used for field testing, and contained 2,3,7,8 TCDD. Analyses were made using GC/MS/MS techniques. The results of testing are shown in Table III.

Table III - Results of Laboratory Testing at Low Agitation, 125 °C

Reaction time, hours	TCDD level, ppb
0	175
1.5	15.1
4.25	2.06
7.0	0.3

These data indicate that the reaction time for samples with low rates of mixing are on the order of 2-3 times longer than those for samples with high rates of mixing, but still well below 8 hours.

Field Test Results

Field testing for this test series consisted of a series of runs using 30 kg. soil samples taken from a dioxin site in Mississippi. Herbicide Orange had been stored at this site, with some spillage, causing soil contamination.

Test equipment for this series of tests is shown in Figure 2 below;

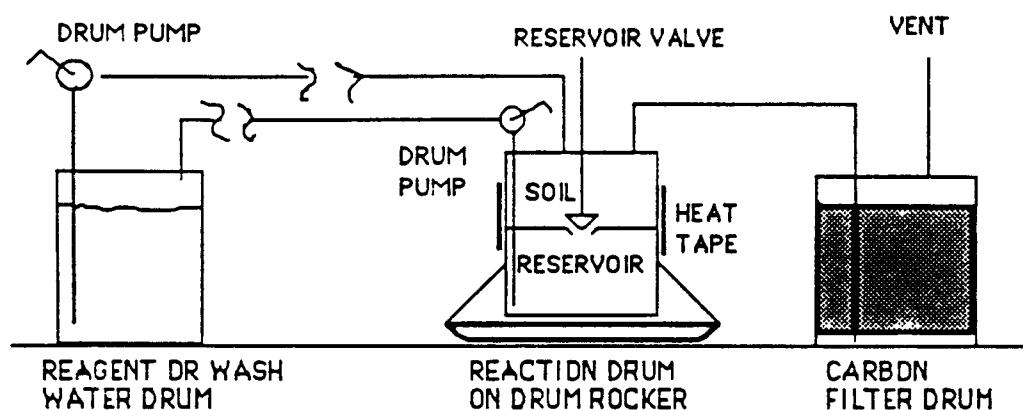


Figure 2 - Apparatus for Field Soils Processing

A 55 gallon drum was modified by the addition of a steel plate halfway down the drum. The plate was pierced by a valve and by a tap to allow pumping of liquids out of the reservoir. The steel plate was sealed with a silicone sealant around the perimeter of the plate. Contaminated soil and reagents were added to the drum by weight. The drum was then covered and a vent line attached between the drum and a carbon filter. A heat tape was wrapped around the drum and the entire drum was insulated with fiberglass. The insulated drum was placed on a drum rocker and rocked from side to side to mix the soil and reagent during heating and reaction. The results of the testing are shown in Table IV.

Table IV - Results of Field Testing

Reaction time, hours	TCDD level, ppb	
	Initial	Final
1.0	154	37.3
2.5	356	10.7
6.5	equipment failure	

The equipment failure occurred at the seal around the perimeter of the steel plate holding the soil/reagent slurry out of the reservoir. In the 6.5 hour run this seal failed, allowing the reagent to separate from the soil and stop the reaction. As noted in the laboratory testing, the reagent is very corrosive to polymers, including Teflon. Seal material selection will be studied in depth prior to scaleup of this process.

Discussion of Laboratory and Field Data

The data from the three series of tests is summarized in Figure 3 below;

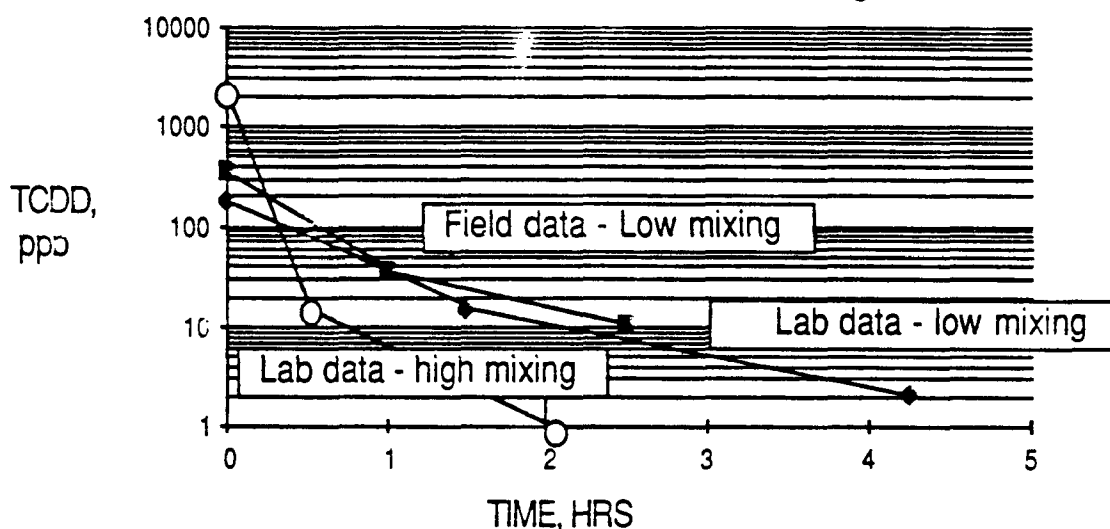


Figure 3 - Results of Soils Processing

Three points can be noted from these data;

1. For each reaction, an initial rate of reaction is followed by a second lower rate of reaction, vs. the single line reaction plot expected for a single order reaction.
2. The laboratory data for the high mixing case indicate a higher rate of reaction than for the lower rate of mixing. This difference is primarily in the initial reaction rate, while the secondary reaction rate is closer to that for the low mixing case.
3. The rates of reaction for field tests and for laboratory tests at low agitation rates are very similar.

The bimodal reaction rate is characteristic for soils treated by this process but not for oil treatment where a single line reaction plot is observed. This dual reaction rate may be due to the heterogeneity of soils. Organics on soils may be adsorbed on the surface of the soil particles, in the micropores of the soil or even wrapped up in the helical humic structures present in some soils. A bimodal reaction rate would be consistent with a process where extraction of the dioxin from the soil into the reagent is the rate limiting step. Extraction of dioxin from the micropores would be expected to be much slower than from the surface of the soil particles. This is consistent with overall rate data showing that the rate of reaction is much higher for liquids than for soils, indicating an extraction limited process.

The micropore/soil surface phenomenon may also explain why the high mixing case shows a much greater difference in initial and final reaction rates than those for the low mixing case. Despite the fact that the soil for all tests came from the same site, the soils for the high mixing case were spiked with dioxin on the same day as the soil was processed. By contrast, the low mixing case soils had weathered for more than five years. It may be that weathering may change the micropore/soil surface distribution of the adsorbed dioxin, possibly by differential volatilization of the dioxin from the surface or by successive displacement of the dioxin by other materials.

The low mixing data for laboratory and field data show a very high degree of correlation. If placed on a normalized graph, these data fall on a single line, as shown below;

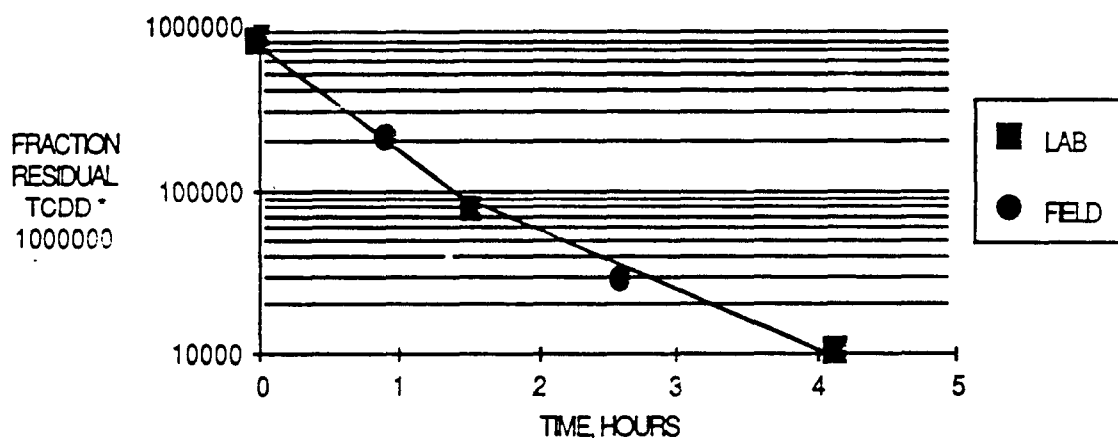


Figure 4 - Comparison of Laboratory and Field Data at Low Agitation

This indicates that the 100:1 scaleup of the process was successful in demonstrating that the procedure is not strongly dependent on sample size.

Conclusions

The results of this study can be summarized as follow;

1. Chemical decontamination of dioxin contaminated soils can reduce dioxin levels to < 1 ppb under laboratory conditions using either high or low rates of agitation.
2. Increasing rates of agitation yield increasing rates of reaction, although other factors may also be involved.
3. Field test data at low rates of agitation are very comparable to laboratory data at low rates of agitation.

Acknowledgments

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References.

1. Peterson, U. S. Patent 4,574,013, March 4, 1986.
2. Esposito et. al., EPA-600/2-80-197, p. 187
3. Niosh Registry of Toxic Effects of Chemical Substances, 1981-2

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December 6, 1988

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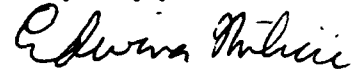
Dear Sir:

Tim Geraets informed me that you need updated information about our APEG process. Enclosed are papers describing final treatment of dioxin contaminated waste streams from Montana Pole and Western Processing Sites, a paper describing a primitive drum-scale remediation of PCB soil at the Bengart & Memel Site, and a paper comparing lab and pilot data for dioxin contaminated soil from Gulfport Mississippi.

We are currently writing the report on the PCB soil pilot study we did this summer at the Wide Beach site and designing a full scale soil treatment unit. We expect to have the treatment unit built by next summer.

If you have any questions or need further information, please feel free to call.

Very truly yours,



Edwina Milicic
Senior Chemist